Particle Capture Rate Workflow

Goal:

To calculate particle capture rate, *k* (s-1), capture rate due to settling, *ks*, capture rate due to collector capture, *kc*, and effective particle capture efficiency, η′ (dimensionless)

Materials:

* Sequoia Scientific LISST-100X
* Nortek Vectrino
* Computer
* R installation

Method:

* derived from Fauria et al., “Suspended particle capture by synthetic vegetation in a laboratory flume”
* refer to Figure 4 in Fauria et al. for a plot of this method

1. Collect particle size data from the LISST instrument in an experiment with dowels and sediment
2. Manipulate the data to obtain a table of particle concentration (μL/L) and time (s)
   1. This step entails summing concentrations from all particle size classes; needs clarification as to the validity of adding up all size classes
3. Fit a first-order exponential decay model according to equation (10) in Fauria et al.,

𝜙a(*t*) = 𝜙a0exp(*-kt*)

where:

* 𝜙a is the particle concentration at a reference height *a* (assumed to be the height of the LISST sensor for our purposes) at time *t*
* 𝜙a0 is the initial particle concentration at *a*
* *k* is the particle capture rate
* *t* is time

1. Obtain estimates for 𝜙a0 and *k* using regression methods
   1. There seems to be many ways to do this, and it is unclear which method is best. In R, I performed this operation by first linearizing equation (10) to obtain rough estimates for log(𝜙a0) and *k*, then using these values as a starting point in a nonlinear least squares fit according to the exponential form.
2. Perform steps 1 to 4 in a control run without dowels/vegetation to obtain *ks*
3. Compute *kc* using the relation *k* = *ks* + *kc*
   1. Fauria et al. suggest scaling this *kc* with a multiplicative constant as defined in equation (11) to account for the increased settling due to greater shear velocity in the presence of collectors, although the method and definition are unclear
4. Compute effective particle capture efficiency, η′, using the relation from equations (3) and (9)

η′ = *kc*/(*udclc*)

where:

* *kc* is particle capture rate
* *u* is flow velocity
* *dc* is collector diameter
* *lc* is stem density

Comparison of Methods:

The development of this routine in R leads to the question of whether it is comparable to the method used by Fauria et al. If the two methods give very different estimates, it is difficult to 1) compare future experiments to those conducted by Fauria et al. and 2) evaluate which estimate is “better.” Ideally, the two procedures should yield very similar estimates for the same data.

1. Fauria et al. found a particle capture rate of 3.95x10-4 s-1 for bin 24 (median particle size: 61.2 microns) in one of their runs (control run 11a). The results of this routine applied to the same run found a particle capture rate of 4.05x10-4 s-1 at the same bin.
2. The method described above was applied to a set of 40 runs from data collected by Fauria et al. for which they had fitted *k* and 𝜙a0 values. The resultant *k* estimates were compared to the estimates derived by Fauria et al. using the nonparametric Wilcoxon rank-sum test. The goal was to see if the methods had any appreciable difference between them.
   1. *p*-value: 0.74
   2. The *p*-value suggests that, at the 0.05 significance level, we should not reject the null hypothesis that there is no stochastic dominance (e.g. sample distributions are identical)
   3. Plots of fitted values suggest that, at higher bins, the values fitted by Fauria et al. are larger than those derived from the procedure developed here
   4. furthermore, this test applied by run (instead of as a whole) yielded all *p*-values much greater than 0.05 (~0.74, with correction for multiple testing with the Benjamini-Hochberg procedure)
3. In additional, a two-sample Kolmogorov-Smirnov test was performed between the Fauria et al. estimates and the estimates derived here
   1. *p*-value: 1
   2. The *p*-value suggests that, at the 0.05 significance level, we should not reject the null hypothesis that the samples are derived from the same distribution
4. The conclusion of these analyses is that the technique described above and that used in Fauria et al. are not appreciably different and thus provide comparable estimates for *k*

Questions/Uncertainties:

* assume all equations and assumptions that Fauria et al. make are valid
* how to compute the scalar correction in step 6
  + equation (11) has terms like *ki* in which *i* denotes particle bin size; are we raising *k* to the power *i*, or does *i* simply refer to the value of *k* for bin size *i*?
* what is *u* exactly in step 7
  + it is not mentioned if *u* is flow velocity at a particular depth or mean velocity